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Guide to Analyzing Investment Options Using TWIGS

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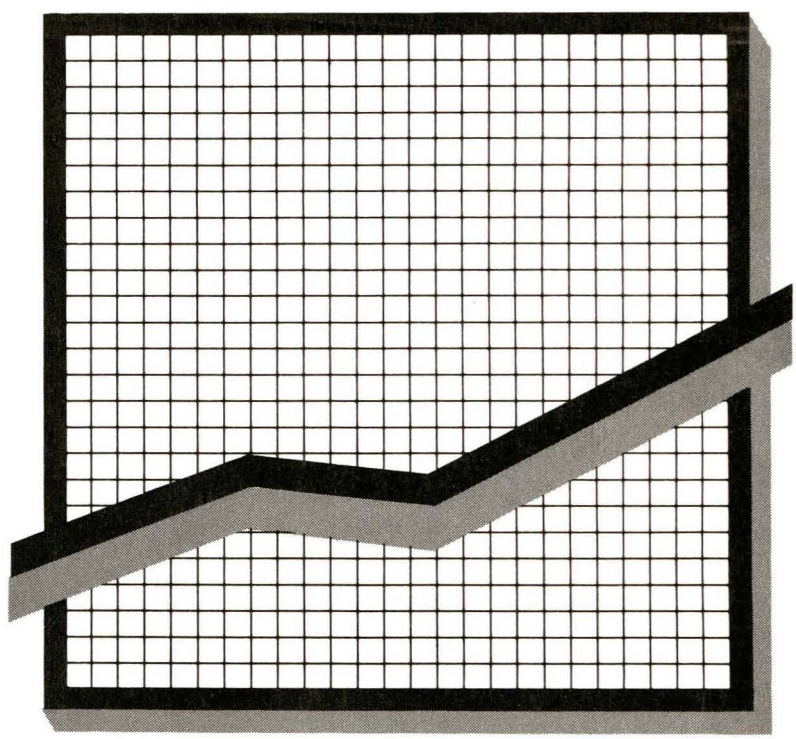

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PREFACE

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GUIDE TO ANALYZING INVESTMENT OPTIONS USING TWIGS

Charles R. Blinn, Dietmar W. Rose, and Monique L. Belli

Forest landowners and managers face a myriad of possibilities when evaluating investment opportunities and potential timber management prescriptions. The various management alternatives need to be identified and evaluated to determine how funds should best be allocated to meet the landowner's or land manager's objectives.

The TWIGS microcomputer program (Belcher 1982, Miner *et al* 1988) can help managers estimate changes in both timber and financial resources under different management prescriptions. TWIGS, a model that projects the growth and death of individual trees in the context of a stand, is a tool that allows forest managers and planners to interactively "manage" and "grow" existing stands with a computer.

The economic analysis of TWIGS version 3.0 summarizes annual cash flows, calculates several measures of economic performance on a before-tax basis, and evaluates the economic uncertainty associated with a management alternative. With this information, forest managers are better able to analyze timber management investment alternatives.

This paper briefly introduces investment analysis concepts and discusses how an analysis might be performed with both the Central and Lake States variants (version 3.0) of TWIGS, expanding on the example found in Miner *et al.* (1988). A separate report describes investment analysis in greater detail (Rose *et al.* 1988).

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BACKGROUND INFORMATION

The components that should be part of any investment analysis include: (1) developing a clear statement of the investor's objectives and time horizon, (2) identifying one or more viable alternatives for meeting each objective, (3) evaluating and comparing the viable alternatives, and (4) implementing and monitoring the appropriate investment(s).

For each investment alternative, the analyst must: (1) determine what management activities will occur and in what year, (2) estimate the amount of money that will be spent or received as well as the degree of uncertainty associated with each cash flow estimate, (3) develop a "cash flow" table that places the appropriate amount in the corresponding year of occurrence, (4) determine the minimal acceptable rate of return (MARR) (an interest rate) required by the investor, (5) calculate and analyze measures of financial profitability, and (6) calculate and analyze the uncertainty associated with the alternative. After all investment alternatives have been evaluated, the one(s) that represent the most efficient use of available resources is implemented and monitored.

If you have little or no experience in woodland management or timber marketing, seek the assistance of a professional forester when undertaking these activities. The forester can provide useful information on timber management alternatives as well as current data for the timing and amount of cash flows that could be expected within your locality. Typical costs that may occur when evaluating timber management alternatives include property taxes, consulting fees, and fees for sale preparation and administration. The selling of standing timber is a typical revenue. Other revenues, such as income from a hunting rights lease, could also be included in the cash flow table if appropriate.

Most States publish stumpage price reviews that can be useful for estimating average prices received for harvested timber (Appendix A). However, stumpage is an unusual commodity that has no exact or "going" price. Instead, the selling price is whatever the buyer and seller agree to and is influenced by many factors, including: (1) species, (2) size, (3) quality, (4) volume of sale, (5) distance to market, (6) site accessibility, (7) logging difficulty, (8) market conditions, (9) buyer's log inventory, and (10) seller's restrictions on harvesting and skidding techniques (Blinn and Hendricks 1985). In addition, because stumpage price reviews cover broad geographic areas, you should use reported prices only to obtain a gross estimate of revenues.

Three general types of cash flows are possible in an analysis:

1. **Single occurrence**: an activity that occurs once during the analysis. An example might be to thin at age 40. You must know the year of occurrence and the amount.
2. **Annual occurrence**: an activity that occurs in each year for 2 or more consecutive years with the same cash flow occurring every year. An example might be annual property taxes. You must know the first and last years of occurrence as well as the amount.
3. **Periodic occurrence**: an activity that costs or returns the same amount every year but does not occur in consecutive years (fertilizing with the same rate of application every 5 years) or an activity that may or may not occur in consecutive years with varying cash flows (Christmas tree shearing costs that vary due to annual differences in number of trees per acre and/or tree size). You must know the number of times the activity occurs and the appropriate amount for each year of occurrence.

Interest is a mechanism for equilibrating the supply and demand for investment capital and savings over time. It can also be thought of as the return that can be obtained from the productive investment of capital or the rent (price) that is paid to lenders for use by borrowers. Although you may not need to borrow money to finance your investments, interest concepts are still appropriate when evaluating investments because capital invested in forestry could be used in an alternative investment (for example, a Certificate of Deposit) that may have a different profitability and associated risk.

Most investment analyses use an appropriate "discount rate" to reflect the notion that a dollar today is worth more than the same dollar 10 years from now. Discounting is a procedure that determines the present worth of a future expected cash flow. The discount rate is sometimes known as the *minimum acceptable rate of return* (MARR). The MARR for an analysis should be your cost of capital. Therefore, an investor who can borrow money at 10 percent would specify a MARR of 10 percent. For an investor who is going to use money that is not borrowed, the MARR becomes the interest rate for the investment account where money is being held (e.g., a savings and loan passbook account, a Certificate of Deposit, a bond, etc.) or the interest rate associated with the most financially attractive viable alternative investment.

Your MARR may change as the overall rate of inflation within the economy changes. Discount rates or MARR's that do not incorporate an overall inflation rate are called *real rates*. A discount rate that contains a real component as well as an overall inflation rate for the whole economy is called a *nominal rate*. A discount rate that is developed directly from a rate quoted from a financial savings and/or lending institution is a nominal rate because it incorporates a real rate as well as the economy's inflation rate. Nominal rates are higher than real rates as long as the inflation rate is greater than zero. Many people prefer to conduct an investment analysis using a nominal discount rate because it is relatively easy to calculate a MARR using savings and loan rates available from financial institutions. However, the implied general inflation rate must still be estimated to conduct the proper analysis. An investment analyzed using a real discount rate should not be compared with an alternative assessed with a nominal discount rate.

Individual cash flows may have different rates of inflation than the overall rate assumed in the analysis. As an example, stumpage rates have historically appreciated faster than the overall inflation rate within the economy. An additional inflation rate may be included for stumpage, if it can be determined. Additional inflation rates for other factors are usually not incorporated because these rates are hard to determine.

Various criteria have been developed for evaluating an investment's performance. Some of the investment performance measures include net present value (NPV), equivalent annual income (EAI), soil expectation value (SEV), benefit cost ratio, payback period, and internal rate of return (IRR). Each of these factors is defined below.

1. **Net present value or present net worth (PNW)**.—Present value of expected revenues minus the present value of expected costs, with all costs

and returns discounted at the MARR. NPV cannot be used to directly compare alternatives with different investment lengths. Investments that have a positive NPV will yield a higher financial return than the MARR used in discounting. If everything is equivalent (risk, investment length, initial investment) between two or more investment alternatives, you would generally select the one that yields the higher positive NPV.

2. **Equivalent annual income or equal annual equivalent.**—Net present value converted to an annual value paid at the end of each year over the life of the investment with interest calculated at the MARR. Because EAI is calculated using NPV, its interpretation is similar to NPV when comparing investment alternatives.

3. **Soil expectation value or the Faustmann formula, bare land value, or land expectation value.**—The value of bare forest land, equivalent to the capitalized value of an infinitely long series of cash flows resulting from timber management. SEV represents the maximum amount that could be paid for a tract of land and still earn the MARR. It is useful for estimating the bid price of bare land for growing successive crops of even-aged timber. Because SEV is defined as the value of bare forest land, forest management alternatives must incorporate all cash flows that occur during a complete management rotation, starting with initial site treatments on bare land, to correctly use this investment criterion. Land purchase costs and land sale returns must be removed from an analysis before a meaningful SEV can be computed. If all criterion assumptions are satisfied, SEV is useful when comparing management alternatives that have different rotation lengths. Where SEV can be applied correctly, select the alternative that has the highest value, given equivalent risk and initial investment.

4. **Benefit cost ratio.**—The present value of discounted revenues divided by the present value of discounted costs. A benefit cost ratio greater than one indicates that discounted benefits exceed discounted costs. If everything is equivalent (risk, investment length, initial investment) between two or more investment alternatives, select the one that yields the higher positive benefit cost ratio.

5. **Payback period.**—The length of time needed for an investment's cumulative annual net cash flows to exceed the required initial investment. Cash flows are generally discounted when this factor is calculated. Investments with short payback periods are sometimes considered to have a lower risk because there is more certainty when estimating cash flows that do not occur far into the future.

6. **Internal rate of return.**—The discount rate that equates the present value of discounted costs and revenues, or the discount rate that would make NPV equal zero. IRR is generally calculated using an iterative process to solve for the appropriate discount rate. An IRR smaller than the MARR used in the analysis indicates that the investment's rate of return is less than the MARR (the investment would also yield a negative NPV). IRR's exceeding the MARR reflect an investment whose rate of return will exceed this alternative rate. You would generally select investment(s) with the highest IRR that exceeded the MARR, given equal risk between investments.

The two most frequently used criteria for comparing investments are NPV and IRR. Although all the various evaluation criteria will favor the same investment alternatives when the decision involves comparing opportunities that are independent (at least two alternatives can be chosen), criteria may differ when investment alternatives are mutually exclusive (only one of the feasible candidate investments can be chosen). The IRR criterion is most appropriate when capital is the primary limiting factor (e.g., no more capital can be borrowed) or when alternatives are independent. The NPV criterion is most appropriate when land is the primary limiting factor (e.g., only one parcel of land is being analyzed) or when alternatives are mutually exclusive.

Evaluate the amount of risk or uncertainty associated with each investment cash flow both before and after analyzing each alternative. Risks are noninsurable losses that may occur, such as physical damage, increases in costs, or decreases in product prices. Although there are several methods for accounting for risk in an investment analysis, sensitivity analysis is a common approach to dealing with this uncertainty (Rose *et al.* 1988). Sensitivity analysis is conducted as a part of an investment analysis to evaluate how a specified change in each cash flow affects the various measures of investment performance.

To avoid biasing the investment decision, establish the degree of confidence for every cash flow estimate before performing the investment analysis. Activities considered to be uncertain, either due to a wide range or variability in amount, and those activities identified as critical factors by the sensitivity analysis deserve further special attention.

You may decide to implement one or more alternatives after performing all the appropriate analyses. Monitoring procedures should be conducted during the implementation phase, as well as throughout the

life of the investment, to increase the chances of financial success. Monitoring will provide invaluable information about the investment status and profitability as well as data that might be useful when analyzing and/or monitoring other investment alternatives. Further information on investment analysis in general and monitoring procedures in particular may be found in Rose *et al.* (1988).

TWIGS INVESTMENT ANALYSIS

A tool such as TWIGS is useful for predicting future timber yields under alternative management strategies when analyzing forestry investments. The TWIGS Economics Menu is shown in figure 1. TWIGS assumes that all cash flows are entered in base year dollars and that they occur at the beginning of the indicated year. Either a real or a nominal discount rate may be used in the analysis, and inflation rates for individual activities can be included. A single additional inflation rate may be specified for all species-product stumpage prices. TWIGS automatically calculates and enters timber harvesting incomes into the diary of cash flows based on user-defined stumpage rates. An explanation of how costs and incomes other than harvesting revenues are entered into TWIGS can be found in Miner *et al.* (1988). A form for developing a cash flow table, for recording the associated uncertainty. and for reporting other information relevant to a forest management investment alternative is presented in Appendix B.

The various investment analysis tables produced by TWIGS include: (1) a summary of cash flow inputs, (2) an annual cash flow summary (an optional output), (3) an analysis of NPV at even discount rates between 0 and 50 percent, (4) a summary of the six investment evaluation criteria defined above, (5) the sensitivity of NPV, EAI, and SEV to a 10-percent change in the original cash flow value for each investment activity, and (6) the percent change, up to 100 percent, for each cash flow value so that NPV will become exactly zero. Although TWIGS does not automatically perform an after-tax analysis, you should consider this factor when comparing alternatives.

EXAMPLE OF AN INVESTMENT ANALYSIS USING TWIGS

Here is an example of how an investment analysis might be conducted using TWIGS. All the various investment analysis steps are presented for the one alternative analyzed.

Scenario

An investor living in northeastern Minnesota wishes to invest about $15,500 in 1987 with investment liquidation to occur in 2007. Further investment monies will be available during this period. The investor is approaching retirement and wants to maximize returns from investing funds.

ECONOMICS MENU:

OPTION	VALUE	DESCRIPTION
A	$ 29.00	Stumpage rate per 1000 board feet of sawtimber (default value).
B	$ 6.00	Stumpage rate per cord of poletimber (default value).
C	$ .00	Stumpage rate per 100 Cuft of residue (default value).
D		Change stumpage rates for a species (0 set, 10 available).
E	0	Annual stumpage price inflation rate (in percent).
F	0	Set option to display cash flow table 0 = Do not display table 1 = Display table
G	1987	Base year for economic analysis (less than or equal to 1987).
H	7.10	Nominal discount rate (in percent).
	2.00	General inflation rate (in percent).
I		See, add or edit the diary of cost and revenue activities (per acre).
J	0	Set option to discount the cash flows. 0 = Discount all cash flows through 2007. 1 = Do not consider cash flows beyond the current projection year (1987).
K		Show economic evaluation on screen.
L		Show economic evaluation on screen & printer.

Type option letter or type Z to continue:

Figure 1.—*Economics menu for setting TWIGS economic parameters.*

Several different alternatives are identified, each of which may meet the investor's objectives. One alternative is to invest all funds in a risk-free savings account that will yield a 7-percent nominal rate of return, including a 4-percent general inflation rate. This 7-percent nominal rate of return was established as the investor's MARR. A second alternative is to purchase a 40-acre tract of land with a 56-year-old natural stand containing red pine, jack pine, white pine, and paper birch. This second alternative is analyzed using the Lake States version of TWIGS.

Investment Analysis Input

The investor employed a forester to inventory the stand, to compile the data into the form of a tree list required by TWIGS, and to develop an appropriate management plan. The tree list for this natural stand is found in a file named LSTLIST on the Lake States TWIGS distribution diskette. A site index of 55 was recorded for red pine during the 1987 inventory. Each acre in the stand currently contains an average of 308 trees, a basal area of 132.9 square feet, and an average d.b.h. of 8.6 inches. Other stand data are shown in Miner *et al.* (1988).

The forester prescribed a thinning from below (taking the smallest trees first) in 1987 to a residual basal area of 90 square feet per acre. Red pine was favored in the residual stand during this commercial thinning. A clearcut was prescribed in 2007.

Stumpage prices assumed in the analysis were representative of prices received from public land in Minnesota (Minnesota Department of Natural Resources 1986) (Appendix A). The investor and the forester agreed on a 1.2-percent annual stumpage price inflation rate, the average real rate of increase for all species across all public timber sales in Minnesota during 1974-1984[1].

Investment cash flows representative of expected costs and returns for the local area, as well as the associated cash flow uncertainties, were then estimated (Appendix C). The purchase of the tract (buy land) is an example of a single occurrence activity. Property taxes and sale preparation expenses represent annual and periodic occurrence activities, respectively. The sale of the land at the end of the investment represents the income that the investor believes could be received from selling bare land. All costs associated with employing the forester at the beginning of the analysis are included in 1987 sale preparation expenses.

[1]*Personal communication with D. Ford, Economist, Minnesota Department of Natural Resources, Division of Forestry, St. Paul, MN.*

The investor and the forester are fairly certain of the cash flow estimates for the 1987 thinning sale income. Cash flow estimates for the 2007 clearcut sale and the income received due to selling the bare land are both highly uncertain. The investor must pay special attention to these uncertainties when evaluating TWIGS economic analysis outputs.

Investment Analysis Output

The abbreviated TWIGS cash flow table presented in table 1 summarizes a portion of the data necessary to calculate the various measures of investment performance. The table is primarily a listing of the cash flow amounts for each year of the investment, incorporating inflation where appropriate. Four cost and three revenue activities are included in the analysis. The two sale incomes were automatically calculated and entered in table 1 as a result of management treatments prescribed (thin from below to 90 square feet of basal area in 1987, favoring red pine, and clearcut in 2007). Cash flow tables also present total expenditures and receipts and net revenues for each year in the analysis. All cash flows that do not occur in the analysis base year (1987) are inflated by the appropriate rate. Note, for example, that the cash flow associated with the sale income that occurs in 2007 is $2,745.51. This amount was calculated according to the following formula:

$$a\,(1 + gi)^{n-1}\,(1 + ai)^{n-1}$$

where: a = current price in 1987 ((stumpage rate times cut volume), totaled for all species)
gi = general inflation rate (0.04)
ai = additional annual inflation rate (0.012)
n = period of occurrence (21; n−1 = 20).

Therefore, the 2007 "SALE INCOME" cash flow was calculated as:

$$\$987.07(1 + 0.04)^{20}\,(1 + 0.012)^{20} = \$2{,}745.51^{2}$$

Table 2 provides a profile of net present values for the investment at various discount rates. This allows an assessment of the effect of different discount rates on net present value. The column displaying nominal discount rates would not appear in a real analysis.

[2]*Hand calculated numbers may not always agree with TWIGS calculations at the hundredth decimal place due to rounding differences.*

Table 1. A portion of the annual cash flow table for the red pine timber management alternative[1]

ANNUAL CASH FLOW PATTERN

(ALL VALUES ARE IN BASE YEAR DOLLARS PER ACRE INFLATED TO YEAR OF OCCURRENCE)

	YEAR				
ITEM	1987	1988	...	2006	2007
Buy Land	300.00	.00	...	.00	.00
Property Tax	.90	.94	...	1.90	1.97
Sale Prep.	65.00	.00	...	.00	142.42
Sale Admin.	22.00	.00	...	.00	48.20
TOT ANN COST	387.90	.94	...	1.90	192.60
CUM TOT COST	387.90	388.84	...	413.80	606.40
Sell Land	.00	.00	...	.00	657.34
SALE INCOME	82.95	.00	...	.00	.00
SALE INCOME	.00	.00	...	.00	2745.51
TOT ANN RECP	82.95	.00	...	.00	3402.85
CUM TOT RECP	82.95	82.95	...	82.95	3485.80
ANN NET REV	-304.95	-.94	...	-1.90	3210.25
CUM NET REV	-304.95	-305.88	...	-330.85	2879.40

[1]SALE INCOME was calculated by TWIGS. Other items (shown in upper and lower case letters) were entered by the user.

Table 2. A portion of the profile of net present values at various discount rates for the red pine timber management alternative, as determined by TWIGS

PROFILE OF NET PRESENT VALUE (NPV) FOR THE INVESTMENT AT VARIOUS DISCOUNT RATES
(INVESTMENT LENGTH = 21 YEARS)

(NPV VALUES ARE IN BASE YEAR DOLLARS PER ACRE)

REAL RATE	NOMINAL RATE	NPV
.00%	4.00%	$ 1143.07
2.00%	6.08%	$ 666.92
4.00%	8.16%	$ 351.89
6.00%	10.24%	$ 141.84
8.00%	12.32%	$ .75
10.00%	14.40%	$ -94.70
12.00%	16.48%	$ -159.69
•	•	•
•	•	•
•	•	•
48.00%	53.92%	$ -306.25
50.00%	56.00%	$ -306.31

The before-tax measures of investment performance are shown in table 3. The nominal internal rate of return would not be displayed if a real analysis had been conducted. All investment performance measures, except internal rate of return, are calculated at the user-specified MARR (7-percent nominal rate in this analysis).

The investment performance measures (table 3) indicate that the investment meets the investor's minimum acceptable rate of return (7-percent nominal rate). In fact, the investment yields a 7-percent nominal rate of return plus $511.61/acre today or $34.02/acre/year over the course of the investment. Discounted benefits exceed discounted costs by a ratio of 2.14 to 1.00. Cumulative net discounted cash flows will recover the initial investment of $304.95/acre ($387.90 in costs minus $82.95 in revenue) for buying the land and paying property taxes, and sale preparation and sale administration expenses after discounting 20 years of cash flows. Finally, the net present value is positive for all real discount rates less than 8.01 percent and for all nominal discount rates less than 12.33 percent. The soil expectation value, although calculated, is not an appropriate economic performance measure for this management alternative because the underlying SEV assumptions have not been met.

Although this investment seems financially attractive, sensitivity analysis data must be interpreted to evaluate the risk associated with this alternative. Table 4 shows the sensitivity of the investment performance measures NPV, EAI, and SEV to a 10-percent change in the input cash flow values for all activities. Increases in costs and/or decreases in revenues decrease NPV, EAI, and SEV by the dollar amounts indicated in the table. Conversely, decreases in costs and/or increases in revenues will increase the performance measures. The larger the dollar amount indicated in table 4, the greater the impact of a 10-percent change in the initial cash flow. As before, SEV criteria were not met for this investment alternative so interpretation of SEV sensitivity analysis data is not appropriate.

In this example, the greatest impact on NPV and EAI would result from changes in revenues associated with the sale income that occurs in 2007 when the stand is clearcut. If revenues received for this activity decreased by 10 percent, NPV would decrease by $70.95/acre and EAI would decrease by $4.72/acre/year. Similarly, NPV would decrease by $16.99/acre and EAI would decrease by $1.13/acre/year if land sale revenues decreased by 10 percent.

Table 3. Summary of economic performance measures at a 7- percent nominal discount rate for the red pine timber management alternative, as determined by TWIGS[1,2]

INVESTMENT PERFORMANCE ANALYSIS

NOMINAL DISCOUNT RATE = 7.00% GENERAL INFLATION RATE = 4.00%
(INVESTMENT LENGTH = 21 YEARS)

(ALL MONETARY VALUES ARE IN BASE YEAR DOLLARS PER ACRE)

NET PRESENT VALUE (NPV)	$ 511.61
EQUIVALENT ANNUAL INCOME (EAI)	$ 34.02
SOIL EXPECTATION VALUE (SEV)	$ 1179.46
BENEFIT/COST RATIO	2.14
YEARS TO PAY BACK AT DISCOUNT	20 YEARS
REAL INTERNAL RATE OF RETURN	8.01%
NOMINAL INTERNAL RATE OF RETURN	12.33%

[1]The real and nominal internal rates of return are calculated independent of the specified discount rate.
[2]Although Soil Expectation Value (SEV) was calculated, this criterion is meaningless because all SEV assumptions were not satisfied.

Table 4. Sensitivity analysis to a 10-percent change in individual activity cash flows for the red pine timber management alternative, as determined by TWIGS[1]

SENSITIVITY ANALYSIS

(SENSITIVITY OF PERFORMANCE TO A 10% CHANGE IN INPUT VALUES)
NOMINAL DISCOUNT RATE = 7.00% GENERAL INFLATION RATE = 4.00%
(INVESTMENT LENGTH = 21 YEARS)

(ALL MONETARY VALUES ARE IN BASE YEAR DOLLARS PER ACRE)

ITEM CHANGED	NPV CHANGE	EAI CHANGE	SEV CHANGE
Buy Land	$ 30.00	$ 2.00	$ 69.16
Property Tax	$ 1.44	$ .10	$ 3.33
Sale Prep.	$ 10.18	$ .68	$ 23.47
Sale Admin.	$ 3.45	$ .23	$ 7.94
Sell Land	$ 16.99	$ 1.13	$ 39.16
SALE INCOME	$ 8.30	$ .55	$ 19.12
SALE INCOME	$ 70.95	$ 4.72	$ 163.56

[1]Although a sensitivity analysis for Soil Expectation Value (SEV) was performed, the values displayed are meaningless because all SEV assumptions were not satisfied.

Although the "buy land" activity has the second highest sensitivity shown in table 4, the investor need not be overly concerned about the potential impact on the investment's profitability. This cash flow occurs at the beginning of the investment period and was estimated with certainty.

In addition to relative impacts on the investment performance measures, specific impacts can also be calculated. For example, NPV for the investment was calculated to be $511.61/acre (table 3). If the annual property taxes costs had decreased by 10 percent to $0.81/acre, NPV would be $511.61 + $1.44 or $513.05/acre. The same logic holds for EAI and SEV. On the other hand, if property taxes had increased by 10 percent to $0.99/acre, NPV would decrease by $1.44 to $510.17/acre.

Changes in NPV, EAI, and SEV from variations in several cost and/or revenue cash flows can also be calculated directly from table 4. For example, a 50-percent increase in property taxes would lower NPV by five times the amount of a 10-percent property tax increase (five times $1.44 or $7.20/acre). Combinations of any number of cash flow variations can also be calculated. For example, if all costs were 10 percent higher and all revenues were 15 percent lower than the estimates used in the analysis, NPV would equal $511.61 − $30.00 − $1.44 − $10.18 − $3.45 − 1.5($16.99 + $8.30 + $70.95) = $322.18/acre. In other words, even if the above changes were to occur, the overall investment decision based on NPV would remain the same because the investment becomes attractive in a general sense when NPV is greater than or equal to zero.

Sometimes it is useful to know how much change is necessary in one or more costs and/or revenues to change the investment decision. This information is shown in table 5 using NPV as the investment performance measure with percent change calculated up to 100 percent. In this example, the investor might wish to know how much revenues received from the clearcut in 2007 must decrease to cause NPV to equal zero. This is determined by dividing NPV (table 3) by the corresponding change in that measure (table 4), and then multiplying the result by 10 percent (the percent change specified in table 4). Using 2007 clearcutting income and NPV as an example, the result is the following:

$511.61 / $70.95 = 7.211* 10 percent = 72.11 percent

In other words, a decrease of 72.11 percent for 2007 clearcutting income would result in a NPV of zero. That is, NPV would equal zero if the 2007 clearcutting cash flow were reduced from $2,745.51 to $765.72. The clearcut in 2007 is the only activity that would require less than a 100-percent change in cash

Table 5. Sensitivity analysis showing the percent change in individual activity cash flow, up to a maximum of 100 percent, required to make net present value exactly $0.00 for the red pine timber management alternative, as determined by TWIGS

RISK ANALYSIS

(INPUT VALUE CHANGES WHICH WILL MAKE NPV EXACTLY EQUAL TO $0.00)
NOMINAL DISCOUNT RATE = 7.00% GENERAL INFLATION RATE = 4.00%
(INVESTMENT LENGTH = 21 YEARS)

(ALL MONETARY VALUES ARE IN BASE YEAR DOLLARS PER ACRE)

ITEM CHANGED	PERCENT CHANGE	DOLLAR CHANGE
Buy Land	100.00%	$ -300.00
Property Tax	100.00%	$ -14.43
Sale Prep.	100.00%	$ -101.80
Sale Admin.	100.00%	$ -34.46
Sell Land	-100.00%	$ -169.87
SALE INCOME	-100.00%	$ -82.95
SALE INCOME	-72.11%	$ -511.61

NOTE: WHEN PERCENT CHANGE EQUALS 100% AND DOLLAR CHANGE IS SMALLER THAN $ 511.61, THE INPUT VARIABLE WILL NOT ALTER THE OVERALL INVESTMENT SELECTION, GIVEN THE CURRENT DECISION CRITERIA.

flow to reduce NPV to zero. As an example, if annual property taxes increase by 100 percent (i.e., double) to $1.80/acre/year, NPV would decrease by $14.43/acre to $497.18/acre. Similar calculations can also be performed for EAI and SEV using information presented in tables 3 and 4.

Investment Analysis Decisionmaking

Based solely on an assessment of investment performance measures (table 3), the investor may decide to implement this alternative. However, sensitivity analysis indicates that investment performance is somewhat sensitive to changes in estimated revenues from the clearcut in year 2007. Before performing the analysis, the investor and forester determined that the 2007 clearcutting income cash flow estimate is very uncertain (Appendix C). If any combination of factors, such as poor markets, decreased yield, disease, or lower rates of real stumpage price increase (less than the 1.2 annual percentage rate assumed) were to cause estimates for this cash flow to decrease by more than 72.11 percent, NPV would be less than zero. Any increases in cost activity cash flows without an increase in revenues would further reduce this percentage. The investor should also consider that the actual growth and yields differ from one location to another and TWIGS only provides an estimate of the regional average. Also, because TWIGS only performs a before-tax analysis, the investor would be wise to examine the implications of tax on the investment's performance. This information, combined with the economic performance data (table 3), should be evaluated when comparing this alternative to other potential investment alternatives.

The investor should perform similar analyses for other investment alternatives. Some of these alternatives might involve different management scenarios for the same timber stand. The risk and uncertainty associated with each alternative should be assessed and compared.

An investor who favors safe investments (a risk-averse investor) would probably avoid our example alternative in favor of an investment yielding a secure 7-percent nominal rate of return. Investors who seek returns greater than a secure 7-percent nominal rate of return, even if the risk is greater (risk-neutral or risk-seeking investors), would probably choose to invest in the 40-acre tract of land. If so, the investor should monitor the investment both during implementation and every year before 2007.

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APPENDIX A

SUMMARY OF PUBLISHED STUMPAGE PRICE REVIEWS FOR THE NORTH CENTRAL REGION [1,2]

State	Title	Source	Publications/Year
Illinois	Illinois Timber Prices Survey	IL Dept. of Agriculture Box 19283 Springfield, IL 62794-9283	2
Indiana	Forest Products Marketing and Wood Utilization Report	Dept. of Forestry and Natural Resources Purdue University West Lafayette, IN 47907	4
Michigan	Timber Mart-North	F. W. Norris P.O. Box 1278 Highlands, NC 28741	4
Minnesota[3]	Public Stumpage Price Review	MN DNR Div. of Forestry 500 Lafayette Road St. Paul, MN 55155	1
Missouri[4]	Missouri Log Market Report	Extension Forester Univ. of Missouri-Columbia School of Forestry 1-34 Ag. Bldg. Columbia, MO 65201	4
Wisconsin	Forest Products Price Review - Boltwood Edition (Boltwood Prices) and Timber Edition (Sawtimber Prices)	Extension Forester Department of Forestry University of Wisconsin 1630 Linden Drive Madison, WI 53706	2 (each bulletin)

[1] Iowa does not regularly publish stumpage price reviews.
[2] There may be a cost associated with receiving some of the price reviews.
[3] Only stumpage prices from public timberland are reported.
[4] Only delivered prices at the mill are reported. Logging and transportation costs would need to be deducted from the reported data to determine stumpage prices.

APPENDIX B

INVESTMENT ANALYSIS PREPARATION FORM

Analyst's Name: _____
Date: ___/___/___

1. **General Description**

   Base Year for Analysis: _____

   Last Year in Which an Activity Occurs: _____

   Investment Size (acres): _____

   Real Discount Rate: __ percent or

   Nominal Discount Rate: __ percent and General Inflation Rate: __ percent

2. **Activity Descriptions**

   Number of Cost Activities: ____

   Number of Revenue Activities: ____

Activity Name	Annual Inflation Rate (Percent[1])	Type of Occurrence[2]	Year(s) of Occurrence	Cash Flow in Base Year Dollars[3]	Degree of Confidence in Estimate[4]	Comments

[1] The percent by which the activity's inflation rate is different from the general inflation rate specified above.
[2] Single (S), annual (A), or periodic (P) occurrence.
[3] Enter cash flows on a per-acre basis with a minus (-) sign for costs and a plus (+) sign for receipts.
[4] Certain (C), fairly certain (FC), uncertain (UC), highly uncertain (HU). The analyst may also choose to enter a range or other measure of variability.

APPENDIX B. Investment analysis preparation form (continued)

Analyst's Name: _____
Date: ___/___/___

Activity Name	Annual Inflation Rate (Percent[1])	Type of Occurrence[2]	Year(s) of Occurrence	Cash Flow in Base Year Dollars[3]	Degree of Confidence in Estimate[4]	Comments

[1] The percent by which the activity's inflation rate is different from the general inflation rate specified above.
[2] Single (S), annual (A), or periodic (P) occurrence.
[3] Enter cash flows on a per-acre basis with a minus (-) sign for costs and a plus (+) sign for receipts.
[4] Certain (C), fairly certain (FC), uncertain (UC), highly uncertain (HU). The analyst may also choose to enter a range or other measure of variability.

APPENDIX C

ECONOMIC INPUTS FOR THE ANALYSIS OF A 56-YEAR-OLD RED PINE STAND

Analyst's Name: R. Forester
Date: 12 /15 /87

1. **General Description**

Base Year for Analysis: 1987

Last Year in Which an Activity Occurs: 2007

Investment Size (acres): 40 Acres

Real Discount Rate: __ percent or

Nominal Discount Rate: 7 percent and General Inflation Rate: 4 percent

2. **Activity Descriptions**

Number of Cost Activities: 4

Number of Revenue Activities: 3

Activity Name	Annual Inflation Rate (Percent[1])	Type of Occurrence[2]	Year(s) of Occurrence	Cash Flow in Base Year Dollars[3]	Degree of Confidence in Estimate[4]	Comments
Buy Land	0	S	1987	-300.00	C	--
Property Taxes	0	A	1987-2007	-0.90	FC	Estimates reliable for near future only.
Sale Prep.	0	P	1987	-65.00	UC	Estimates reliable for near future only.
			2007	-65.00		Dependent on cost & availability of labor

[1] The percent by which the activity's inflation rate is different from the general inflation rate specified above.
[2] Single (S), annual (A), or periodic (P) occurrence.
[3] Enter cash flows on a per-acre basis with a minus (-) sign for costs and a plus (+) sign for receipts.
[4] Certain (C), fairly certain (FC), uncertain (UC), highly uncertain (HU). The analyst may also choose to enter a range or other measure of variability.

APPENDIX C. Economic inputs for the analysis of a 56-year-old red pine stand (continued)

Analyst's Name: R. Forester
Date: 12 /15 /87

General Description

Activity Name	Annual Inflation Rate (Percent[1])	Type of Occurrence[2]	Year(s) of Occurrence	Cash Flow in Base Year Dollars[3]	Degree of Confidence in Estimate[4]	Comments
Sale Admin.	0	P	1987	-22.00	UC	Estimates reliable for near future only.
			2007	-22.00		Dependent on cost & availability of labor
Sell Land	0	S	2007	+300.00	HU	Uncertainty in future market for land.
Sale Income[5]	1.20	S	1987	+82.95	FC	--
Sale Income[5]	1.20	S	2007	+987.07	HU	Uncertainty in future prices and markets

[1] The percent by which the activity's inflation rate is different from the general inflation rate specified above.
[2] Single (S), annual (A), or periodic (P) occurrence.
[3] Enter cash flows on a per-acre basis with a minus (-) sign for costs and a plus (+) sign for receipts.
[4] Certain (C), fairly certain (FC), uncertain (UC), highly uncertain (HU). The analyst may also choose to enter a range or other measure of variability.
[5] Sale income revenues are automatically calculated by the ECON subroutine in TWIGS and entered into the diary of cost and revenue activities.

Blinn, Charles R.; Rose, Dietmar W.; Belli, Monique L.
1988. Guide to analyzing investment options using TWIGS. Gen. Tech. Rep. NC-123. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station. 15 p.

Describes methods for analyzing economic return of simulated stand management alternatives in TWIGS. Defines and discusses net present value, equivalent annual income, soil expectation value, and real *vs.* nominal analyses. Discusses risk and sensitivity analysis when comparing alternatives.

KEY WORDS: Economic analysis, simulation, financial uncertainty, sensitivity analysis, risk.